EXHIBIT N

OMNIBUS BROWN DECLARATION

Principles of Econometrics

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R.Carter Hill

Louisiana State University

William E. Griffiths

University of Melbourne

Guay C. Lim

University of Melbourne

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10 intervals, those for samples 4 and 6 do not contain the true parameter $\mu = 10$. Nevertheless, in 10,000 simulated samples 94.82% of them contain the true population mean $\mu = 10$.

C.5.5 Interval Estimation Using the Hip Data

We have introduced the empirical problem faced by an airplane seat design engineer. Given a random sample of size $N = 50$ we estimated the mean U.S. hip width to be $\bar{y} = 17.158$ inches. Furthermore we estimated the population variance to be $\hat{\sigma}^2 = 3.265$; thus the estimated standard deviation is $\hat{\sigma} = 1.807$. The standard error of the mean is $\hat{\sigma}/\sqrt{N} = 1.807/\sqrt{50} = 0.2556$. The critical value for interval estimation comes from a t-distribution with $N - 1 = 49$ degrees of freedom. While this value is not in Table 2, the correct value using our software is $t_c = t_{(0.975,49)} = 2.0095752$, which we round to $t_c = 2.01$. To construct a 95% interval estimate we use (C.15), replacing estimates for the estimators, to give

$$\begin{aligned}\bar{y} \pm t_c \frac{\hat{\sigma}}{\sqrt{N}} &= 17.1582 \pm 2.01\,\frac{1.807}{\sqrt{50}} \\ &= [16.6447,\ 17.6717]\end{aligned}$$

We estimate that the population mean hip size falls between 16.645 and 17.672 inches. Although we do not know if this interval contains the true population mean hip size for sure, we know that the procedure used to create the interval "works" 95% of the time; thus we would be surprised if the interval did not contain the true population value μ.

C.6 Hypothesis Tests About a Population Mean

Hypothesis testing procedures compare a conjecture, or a hypothesis, that we have about a population to the information contained in a sample of data. The conjectures we test here concern the mean of a normal population. In the context of the problem faced by the airplane seat designer, suppose that airplanes since 1970 have been designed assuming the mean population hip width is 16.5 inches. Is that figure still valid today?

C.6.1 Components of Hypothesis Tests

Hypothesis tests use sample information about a parameter namely, its point estimate and its standard error to draw a conclusion about the hypothesis. In every hypothesis test, five ingredients must be present:

COMPONENTS OF HYPOTHESIS TESTS

A *null* hypothesis, H_0
An *alternative* hypothesis, H_1
A test *statistic*
A *rejection* region
A conclusion

C.6.1a The Null Hypothesis

The "null" hypothesis, which is denoted H_0 (*H-nought*), specifies a value c for a parameter. We write the null hypothesis as $H_0: \mu = c$. A null hypothesis is the belief we will maintain until we are convinced by the sample evidence that it is not true, in which case we *reject* the null hypothesis.

C.6.1b The Alternative Hypothesis

Paired with every null hypothesis is a logical alternative hypothesis, H_1, that we will accept if the null hypothesis is rejected. The alternative hypothesis is flexible and depends to some extent on the problem at hand. For the null hypothesis $H_0: \mu = c$ three possible alternative hypotheses are

- $H_1: \mu > c$. If we reject the null hypothesis that $\mu = c$, we accept the alternative that μ is greater than c.
- $H_1: \mu < c$. If we reject the null hypothesis that $\mu = c$, we accept the alternative that μ is less than c.
- $H_1: \mu \neq c$. If we reject the null hypothesis that $\mu = c$, we accept the alternative that μ takes a value other than (not equal to) c.

C.6.1c The Test Statistic

The sample information about the null hypothesis is embodied in the sample value of a **test statistic**. Based on the value of a test statistic, we decide either to reject the null hypothesis or not to reject it. A test statistic has a very special characteristic: its probability distribution is completely known when the null hypothesis is true, and it has some other distribution if the null hypothesis is not true.

Consider the null hypothesis $H_0: \mu = c$. If the sample data come from a normal population with mean μ and variance σ^2, then

$$t = \frac{\overline{Y} - \mu}{\hat{\sigma}/\sqrt{N}} \sim t_{(N \quad 1)}$$

If the null hypothesis $H_0: \mu = c$ is true, then

$$t = \frac{\overline{Y} - c}{\hat{\sigma}/\sqrt{N}} \sim t_{(N \quad 1)} \tag{C.16}$$

If the null hypothesis is not true, then the t-statistic in (C.16) does not have the usual t-distribution.

> **REMARK:** The test statistic distribution in (C.16) is based on an assumption that the population is normally distributed. If the population is not normal, then we invoke the central limit theorem, and say that $\overline{Y}$ is approximately normal in "large" samples. We can use (C.16), recognizing that there is an approximation error introduced if our sample is small.

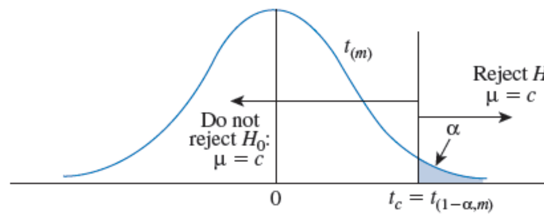

FIGURE C.5 The rejection region for the one tail test of $H_0 : \mu = c$ against $H_1 : \mu > c$.

C.6.1d The Rejection Region

The rejection region depends on the form of the alternative. It is the range of values of the test statistic that leads to rejection of the null hypothesis. They are values that are *unlikely* and have low probability of occurring when the null hypothesis is true. The chain of logic is "If a value of the test statistic is obtained that falls in a region of low probability, then it is unlikely that the test statistic has the assumed distribution, and thus it is unlikely that the null hypothesis is true." If the alternative hypothesis is true, then values of the test statistic will tend to be unusually large or unusually small. The terms "large" and "small" are determined by choosing a probability α, called the **level of significance** of the test, which provides a meaning for "an *unlikely* event." The level of significance of the test α is usually chosen to be 0.01, 0.05, or 0.10.

C.6.1e A Conclusion

When you have completed a hypothesis test, you should state your conclusion, whether you reject the null hypothesis. However, we urge you to make it standard practice to say what the conclusion means in the economic context of the problem you are working on that is, interpret the results in a meaningful way. This should be a point of emphasis in all statistical work that you do.

We will now discuss the mechanics of carrying out alternative versions of hypothesis tests.

C.6.2 One-Tail Tests with Alternative "Greater Than" (>)

If the alternative hypothesis $H_1 : \mu > c$ is true, then the value of the t-statistic (C.16) tends to become larger than usual for the t-distribution. Let the critical value t_c be the $100(1-\alpha)$-percentile $t_{(1\ \alpha,N\ 1)}$ from a t-distribution with $N-1$ degrees of freedom. Then $P(t \leq t_c) = 1-\alpha$, where α is the level of significance of the test. If the t-statistic is greater than or equal to t_c, then we reject $H_0 : \mu = c$ and accept the alternative $H_1 : \mu > c$, as shown in Figure C.5.

If the null hypothesis $H_0 : \mu = c$ is *true*, then the test statistic (C.16) has a t-distribution, and its values would tend to fall in the center of the distribution, where most of the probability is contained. If $t < t_c$, then there is no evidence against the null hypothesis, and we do not reject it.

C.6.3 One-Tail Tests with Alternative "Less Than" (<)

If the alternative hypothesis $H_1 : \mu < c$ is true, then the value of the t-statistic (C.16) tends to become smaller than usual for the t-distribution. The critical value $-t_c$ is the 100-percentile $t_{(\alpha,N\ 1)}$ from a t-distribution with $N-1$ degrees of freedom. Then $P(t \leq -t_c) = \alpha$, where α